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UNITED STATES
DEPARTMENT OF AGRICULTURE
CIRCULAR No. 474

Washington, D. C. MAY 1938

MUSKRAT INVESTIGATIONS IN DORCHESTER COUNTY, MD. 1930–34

By

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Bureau of Biological Survey

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PURPOSE OF THE INVESTIGATIONS

The muskrat ranks first among the fur animals of North America in the number and total value of pelts marketed. It has been estimated that in Maryland alone it produces an annual revenue of $2,500,000 (*14*).[1] Although for many years the animal has been trapped for both meat and fur, its life history and habits are still little known. Almost any trapper or fur dealer can tell something of its habits, but when their stories are compared they are found to have little in common. Information thus gained lacks scientific value, as it is based largely on beliefs and legends and on meager, unsystematized observations made while running trap lines in winter.

In order to gather accurate information on the muskrat of the Eastern Shore Peninsula, the Conservation Department of Maryland, the Agricultural Experiment Station of the University of Maryland, and the Bureau of Biological Survey, United States Department of Agriculture, through its Section of Fur Resources, united in a project to study the life history of this important fur producer, with particular attention to be given to its breeding habits and to the feasibility of raising it profitably in pens. The investigations here reported were begun in December 1930 with the establishment of a laboratory on a marsh in Dorchester County, Md., the use of which was made possible

[1] Italic numbers in parentheses refer to Bibliography, p. 23.

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through the generosity of the owner, W. A. Gibbs, and were continued through June 1934. Some of the muskrats were confined to pens for detailed observation under controlled conditions.

THE MUSKRAT OF THE EASTERN SHORE

SYSTEMATIC POSITION AND RANGE

There are but three species of muskrat, all very closely related: *Ondatra zibethica*, the common eastern muskrat, which shows considerable variation and has been broken into 13 subspecies; *O. obscura*, the Newfoundland muskrat; and *O. rivalicia*, the Louisiana muskrat. Their nearest living relatives are the lemmings and meadow mice, both of other genera. Fossil remains of *Ondatra* occur, however, in the North American Pleistocene (*8*).

Ondatra zibethica was named in 1766 by Linnaeus as *Castor zibethicus*, meaning the civet, because of its musky odor. He had previously confused it, however, with the desman of Asia. Between 1786 and 1840 the generic name was changed eight times, and thereafter for many years the animal was known as *Fiber*. In 1795 Link gave it the generic name *Ondatra*, an Indian name for the muskrat and the one now in current use.

The muskrat of the Eastern Shore is the Virginia muskrat, *Ondatra zibethica macrodon*, described by Merriam in 1897 from Lake Drummond, Va. It is separated from the other 12 subspecies of *O. zibethica* by being the largest, by its dark color, and by the absence of an interorbital ridge (*9*).

Hollister gives the geographic distribution of *macrodon* as "Middle Atlantic coast region of the United States, from Delaware Bay to Pamlico Sound; inland to Washington, Virginia, and Raleigh, N. C." (*9, p. 18*).

DESCRIPTION

The Virginia muskrat, which has two color phases, black and brown, is a heavy-set, short-necked rodent about 23.5 inches in length, 10 of which are tail. For a description of the skull and teeth Hollister (*9, p. 19*) is quoted: "Skull large, with heavy rostrum, posteriorly elongated brain case, and elevated frontal; jugal massive, high, and rounded above; molar teeth large." The ears are rather small, but easily noticeable, as are the beady black eyes. The mouth is admirably adapted to life beneath the surface of the water. The lips are so formed that they can be closed between the incisors and molars, thus allowing use of the incisors while the mouth is shut. This enables the animal to gnaw while under the surface, as well as to carry food or building material in its mouth while swimming. The legs are short and powerful. The hind feet, about 3.2 inches long, have partly webbed toes and are fringed with stiff hairs, which aid in swimming. The front feet, used in handling food, are small and are not especially adapted for swimming. The long tail is laterally flattened and is covered with scales and very sparse short hair. Well-developed perineal glands secrete musk, particularly during the breeding season.

COLOR VARIATION

Hollister (*9, pp. 18–19*) describes the two color phases of the Virginia muskrat as follows:

Brown phase: Upper parts Prout's brown, darker on nose, head, and back; sides varying from grayish brown to russet; under parts from broccoli brown or drab to bright cinnamon rufous . . .

Black phase: Entire upper parts, sides, and middle area of under parts uniform brownish black; flanks with a few hairs of rusty brown; cheeks rusty; throat and ventral region whitish, drab, or Isabella color; usual small spot on chin black.

Hollister (*9*) says further that there is "every degree of variance" between the black and brown extremes, but in the Maryland specimens examined, the gradation, though marked, is by no means complete, and during the investigations it was never difficult to distinguish black from brown except during immaturity. This is also the experience of trappers and others handling fur in this section.

To study the color phases, a series of experiments was begun in the spring of 1931. Black, brown, and black and brown pairs of muskrats were placed in breeding pens, and the color of their offspring was noted. From the results, shown in table 1, it appears that black parents produce only black young and that brown parents produce either black or brown, with brown more common. Mr. Gibbs, who also has raised muskrats in pens, has made similar observations. Because of the limited data it cannot be definitely stated that the black coloration is a recessive character and the brown a dominant. The data suggest, however, that this is true.

TABLE 1.—*Data on the inheritance of color in muskrats*

Color of parents	Young produced				
	Total	Black		Brown	
	Number	*Number*	*Percent*	*Number*	*Percent*
Both black	13	13	100	0	0
Both brown	26	2	7+	24	92+
1 black, 1 brown	6	2	33+	4	66+

DISPOSITION

Muskrats are very pugnacious toward one another, and fighting on the marsh seems to be very common. Many animals show scars of old wounds, and fresh, unhealed wounds are particularly noticeable toward spring at the beginning of the breeding season. If several animals are confined in a pen, fighting usually results, especially if strange animals are introduced. Animals that have lived together amicably for weeks may begin fighting without apparent reason and continue until one or more are killed.

Many wild animals become tame and friendly when associated with human beings, but muskrats seldom do, although some respond a little to petting. In the course of this work only one adult became tame enough to allow its back to be stroked, but it was always treacherous, on one occasion biting the finger from a glove. Young muskrats make attempts to defend themselves a few days after birth and by the time they are 3 weeks old are able to draw blood.

MUSKRAT MARSHES AND THEIR POPULATION

There are three factors essential to a good muskrat marsh: (1) Abundance of suitable vegetation, (2) plenty of fresh or brackish water, and (3) a bottom with at least 6 inches of peaty plant remains. Although some muskrats will live where one or more of these factors are absent, the maximum population cannot be sustained unless all are present.

As with all other forms of animal life, food is of prime importance to muskrats. If proper food is scarce, muskrats will be scarce; if abundant and easily obtainable, muskrats will abound, unless other factors are unfavorable. Thus, many marshes that seem ideal from a physical viewpoint may lack muskrats because food is scarce and other marshes where the physical factors are adverse may support a fair muskrat population because food is plentiful. Marshes vary slightly as to the chief muskrat food, but it can safely be said that 75 percent of the muskrat food in Maryland marshes consists of three-square sedge and cattails.

Water is also a prime necessity for muskrats, though a great depth is neither essential nor desirable. Fresh or brackish water is best. Salt water kills the favorite food plants, which accounts for muskrat scarcity in salt-water areas. During the unprecedented drought of 1930, the fresh-water marshes under observation were invaded by salt water from Chesapeake Bay with disastrous results. The best food plants of the muskrats were destroyed or seriously depleted, and many of the animals died. Two years later the vegetation had practically regained its normal growth and muskrats were again numerous.

The best muskrat marshes are those in which the normal water level is at or near the ground level. The animals prefer swimming to walking, and in marshes with such a water level they can dig a system of canals and underground tunnels. Not infrequently these highways are concealed by the dense vegetation.

A bottom composed of peaty humus seems to be as important to the muskrat as an abundance of food or water, for in it ideal underground tunnels and canals with firm banks can be dug. No other type of bottom lends itself so readily to such excavation. Sand, although easy for the animals to dig in, caves in, and constant work is required to keep canals in such soil open. Clay is hard to excavate and makes a muddy canal that the animals apparently do not like.

Peaty humus is formed of the remains of many generations of plants that have been buried beneath the water. Decay is slow under such conditions, and the resulting layer may be 5 feet or more in depth. The material is bound together by the roots of living plants, which help it to retain its shape. When dry, this peat can be crumbled by hand and burns rapidly; when wet, it holds its form, although it is easily excavated.

In some places on the marshes only a foot or so of soil at the surface is firm and below this is a thin, black, almost liquid mud that may be several feet deep. When very deep, such mud forms what is known as a bottomless marsh, which when traversed quivers in all directions. The deeper bottomless marshes are not very good for muskrats.

EFFECTS OF FLOODS

Floods of normal proportions on the Maryland marshes usually do not seriously affect muskrats unless other unfavorable factors enter in. The animals may be forced to sleep temporarily on the tops of their houses, but they are soon able to build covered nests there. Some young may be lost, but as a rule such casualties are of little consequence. The hurricane of August 22–23, 1933, however, did great damage. A high wind, accompanied by heavy rain, drove the waters of Chesapeake Bay up over the low marshes 3 to 4 feet higher than ever before recorded. All muskrat houses were either swept away or submerged, and the animals were left without shelter or places to rest.

In the upper marshes, near higher ground, the muskrats were able to build nests on high stumps or in the forks of trees or to find other elevated shelter. On the Gibbs marsh they resorted to the banks, and although some were killed, many more escaped. Near Blackwater Bridge the animals built nests on the parts of a fence that protruded above the water. Here four or five of them could often be seen on a heap of grass no larger than a bushel basket. As time passed and the water remained high, they died one by one, apparently from disease or starvation, until practically all of them were gone.

That winter the marshes near some of the higher islands showed a decided increase in the muskrat population, because of the flood. Survivors from a wide area that had sought safety on the islands had settled on the marshes as the flood waters receded. Thus, some very small areas were well stocked with animals, while others, in which there was an abundance of food, were entirely untenanted.

The lower marshes afforded no elevations on which the animals could seek safety. Their bodies were washed up on the islands in great numbers, one trapper reporting more than 500 (probably an exaggeration) on an island near Shorter's Wharf. The writer found more than 75 skeletons in the drift washed up in the same vicinity (pl. 1, *A*). On one low isolated island, he found two pieces of sod from the marsh that had been washed loose and had floated there to form tiny islands about 1 by 6 feet in extent. On one, there were three muskrat skeletons, and on and around the other, five. Evidently the animals had sought shelter there, only to die of disease or starvation. That fall, marshes that normally yielded the owners a good catch of muskrats showed not a single muskrat house.

Great numbers of muskrats were drowned, but many more succumbed to disease, starvation, and lack of fresh water. Those that escaped the flood by reaching elevated spots soon began to sicken and die, as food was scarce and of poor quality, or unobtainable, and the water, because of the tide, was as salt as that of the bay. In some of the marshes the water remained high for nearly 2 weeks, by which time it had become stagnant. The thousands of dead bodies, not only of mammals, but also of snakes, worms, and other creatures, made a great stench.

Birds of prey and other predators found it easy to take a heavy toll of the animals while they were exposed without houses. Four young muskrats were found in a nest on the ditch bank of the Gibbs marsh, victims of a weasel that had sought shelter there and that had also

killed incredible numbers of marooned meadow mice. The weasel, found a few days after the flood, was too weak to run. Apparently it had slaughtered in one orgy all the animals on the bank and after they had decayed it had starved.

The flood caused the loss of most of the experiment station breeding animals. As soon as the water began to rise, floats were provided for them, and on these they sought safety. By the evening of the second day the water had risen to such a level that some of the animals were able to get over the fence, and perhaps half a dozen escaped. Baited traps were at once set, and a few of the fugitives were recaptured. For the next 2 or 3 days the refugees fed on the small quantity of rubbish that they had piled on their floats. Then they began to die rapidly. Efforts to catch them failed, owing to the depth of the water, and resulted in one muskrat drowning rather than exposing itself to capture. On August 31, it was possible to capture the animals that remained—32 of the original stock of 53. They were placed in small tin shipping crates, the only available containers. Nearly all were sick, and many of them died. Construction of the pens (pl. 1, *B*, *C*) at the new station was pushed to completion, and on September 8, the 13 muskrats then remaining were transported to them. These animals were all sick and, although they apparently recovered, never displayed their former activity. They no longer came out in the daytime or ate as much as they had before the flood. By February, only six were still alive.

The cause of all deaths during the flood could not be determined. Examination of one body while it was still warm showed white blisters on the lungs and intestines bloated with gas. Many animals had sore tails and feet, and some had lost the fur about their heads. This was probably due to some unfavorable property in the water or to the wet surroundings

EFFECTS OF DROUGHT

As the muskrat is an animal of semiaquatic habits, it must have water. Ordinary dry weather, such as is experienced nearly every summer, has no serious effect on the muskrat population of any area, but an extreme drought, like that of 1930, brings catastrophe. As the water level sank lower and lower on the Maryland marshes that year, many muskrats deserted their homes and followed the receding water down the creeks and rivers. Trappers reported that they had gathered along some streams in great numbers. New and unusual conditions were encountered. The water became stale, and the salt water of the bay that replaced the normal fresh or brackish water of the marsh destroyed their favorite food plants. The three-square sedge, their chief food, was killed out in large areas. Cattails seemed to be little affected, but as they grow in patches they are only of local importance. The waterlily, which is eaten to some extent, was exterminated over large areas. The large number of animals soon consumed the best of the available food, and the unusual effort expended in search for more, combined with the inferior quality of that obtained, soon sapped their strength. Thus, deprived of both proper food and water, they practically disappeared on some areas, and very few young were raised that year.

The sudden drop in the muskrat population caused by this long drought is indicated in table 2, which is a record of the animals caught

over a period of years on the Scarborough marsh in Worcester County. In 1931, the catch dropped to about 30 percent of that of the preceding 5 years and no kits—young muskrats—were caught. These data were collected at the request of R. V. Truitt, of the University of Maryland, and were generously supplied by him for this report.

TABLE 2.—*Muskrats caught on Scarborough marsh, 1926-33, showing effects of 1930 drought*

Year	Adults	Kits	Year	Adults	Kits
	Number	*Number*		*Number*	*Number*
1926	3,627	101	1930	4,129	189
1927	4,021	109	1931	1,211	0
1928	3,909	121	1932	1,931	11
1929	3,914	149	1933 [1]		

[1] No records available, but catch reported normal.

EFFECTS OF COLD

A normally cold winter does not bother muskrats, although they may be inconvenienced by the freezing over of the marsh; but occasionally an unusually cold spell, such as that in Maryland in February 1934, when the marshes froze over and remained frozen for nearly the entire month, does great damage. Test holes dug showed that in places the water and mud were frozen to a depth of 6 inches. On marshes where there was plenty of water, the animals were not greatly affected, for they were able to dig out roots for food and to travel under the ice much as usual. On marshes where there was little water, conditions were more serious. Not only the water but the mud beneath froze solid, and the animals were unable to move about beneath the ice or to find roots. Many doubtless perished in their homes, but a large number dug out and wandered about in search of food. Some were found in fields and other places far from the marshes, and great numbers were hidden in bunches of high grass about the marsh, some dead, but others still alive and active. Some trappers used dogs to help them find these animals, a practice that should not be too much condemned under such conditions, as the muskrats thus exposed on top of the ice would have died.

An idea of the great number of muskrats that perished during the freeze-up can be formed from the following figures, representing numbers of bodies found on top of the ice by individual trappers: 103, 25–30, 20, 18–20, 18, 10, 7. The high figures are almost invariably from "ebb-and-flow" marshes where there was little water; the low records, from "still-water" marshes where there was plenty of water.

SEX DISTRIBUTION

On the Gibbs marsh more male than female muskrats are caught, and trappers on other marshes report like results. Whether this is due to a naturally greater number of males, a higher death rate of females, or the trapping methods now used cannot be definitely stated. Johnson (*11*) tells of the observations of two experienced trappers who believe that after muskrats mate, the males go into hiding and the females wander about a great deal more than at other times. When a great many females are caught, these men take up

their traps, believing this to be a sign that the breeding season has commenced. Up to this time, they say, they catch many more males than females. If, as they believe, males are more active during the winter trapping season and females during late winter and early spring, when the trapping season is almost over, a year's catch would yield more males than females. Table 3 presents data on the sex distribution in muskrats, both trapped and penned, on the Gibbs and Scarborough marshes in Maryland.

TABLE 3.—*Sex distribution in trapped and penned muskrats in Maryland*

Year	Males	Females	Total
TRAPPED MUSKRATS, GIBBS MARSH, 1933			
1933:	*Number*	*Number*	*Number*
Feb. 4	38	13	51
Feb. 18	44	24	68
Feb. 20	34	16	50
Mar. 3	27	16	43
Mar. 6	5	10	15
Mar. 9	19	12	31
Total	167	91	258
TRAPPED MUSKRATS, SCARBOROUGH MARSH, 1926–32			
1926	64	66	130
1927	77	21	98
1928	102	69	171
1929	15	19	34
1930	21	20	41
1931	203	198	401
1932	413	296	709
Total	895	689	1,584
PEN-RAISED MUSKRATS, GIBBS MARSH, 1931–32			
1931	10	8	18
1932	16	18	34
Total	26	26	52

The data obtained during the 1933 season on the sex of the muskrats caught on the Gibbs marsh are not sufficient to permit conclusions. They show 64+ percent males to 35+ percent females in the 258 animals recorded.

The records as to the sex of muskrats on Scarborough marsh, Worcester County, kept for 7 years (1926–32) by Lawrence Baughman, the trapper in charge, at the suggestion of Dr. Truitt, through whose courtesy they were made available for comparison with those for the Gibbs marsh, are incomplete in that they were kept only when few animals were caught and for this reason may relate to a period late in the season when animals were scarce and females active. The sex ratio in the 1,584 animals recorded is 56+ percent males to 43+ percent females. Mr. Baughman states that years ago when he trapped late in the season he caught many more females than males, which substantiates Johnson's statement that females are more active late in the season.

The sex ratio of animals raised in pens is probably the most reliable one, as all the animals can be accounted for. The data for the 52

pen-raised animals on the Gibbs marsh that reached sufficient age to have sex accurately determined show that for 2 years (1931, 1932) males and females were nearly equal in number. This suggests that the apparent difference in sex ratio in trapped animals is due to some factor not found among penned animals, such as difference in the seasonal activity of the sexes or the trapping methods used.

ACTIVITY ON THE MARSHES

Late in spring and throughout summer, muskrats on the Maryland marshes are active abroad both during daylight hours and at night. In the daytime they are less active in the morning than later, apparently staying in their houses and burrows during the forenoon. This does not mean that they are never seen at that time, because some individuals are active at all hours during this season. As the afternoon passes, however, they become more lively and are frequently seen swimming about in their canals and foraging. The peak of their daylight activities seems to be reached between sunset and dusk, but the animals are probably increasingly active after darkness makes observation impossible. In dark, cloudy, or rainy weather, activity outside their tunnels is increased throughout the day.

During winter, daylight activity is usually so limited that an animal is seldom seen. Occasionally, however, one is observed swimming under the ice, the air held in its fur giving it a silvery appearance. During prolonged periods of cold weather, night activities also are reduced. When a warm, wet spell comes after a period of cold, the animals become very active. If the nights are very cold, but the days warmer, muskrats are likely to be abroad under the ice during the daylight hours. On February 10, 1933, during such a spell on the Gibbs marsh, the writer saw eight of them swimming about under the ice.

If a muskrat is surprised while swimming it dives at once, the haunches and base of the tail rising from the water for an instant as it goes under. There may or may not be a loud splash. The splash appears to be under the control of the animal and probably serves as a warning to other muskrats. A series of small bubbles usually marks the under-water course. If not badly frightened the muskrat may return to the surface to survey the situation under the protection of grass or other convenient shelter, with only its eyes and nose above water.

SUSPENDED BREATHING

As muskrats spend so much time under water, suspended breathing is often necessary. When the water is open they can of course refill their lungs by coming to the surface, but when the water is frozen over it is often difficult for them to obtain air.

Trappers frequently set their traps so that the animals are forced under the water and drowned, but under normal conditions muskrats are able to remain submerged for a surprisingly long time. Mr. Gibbs reports an interesting observation along this line. As he approached a muskrat caught in a fish trap he saw the animal floating. Knowing that it would dive when he drew nearer, he took out his watch to time its stay under water. Then he walked up to the trap, and as expected the muskrat went under, remaining down for 17

minutes. Then it came to the surface and, seeing the intruder, plunged again, staying under for 10 minutes. It refused to dive again. Mr. Gibbs says that not more than 3 seconds elapsed between the two dives. The animal was in plain sight throughout this observation and could not have obtained air in any way while under the water.

When the marsh is frozen over, the canals in use are indicated by large bubbles under the ice that appear to be the air carried under and exhaled by the muskrats (pl. 1, *D*). It is possible that this air is to some extent reoxygenated, because when muskrats swimming under the ice come to one of these bubbles, they usually stop to refill their lungs. Morgan (*16, p. 138*) reports:

> When swimming under ice he [the muskrat] comes up to its lower surface, and, having expelled the air from his lungs, waits for a moment, and then, after drawing in again the bubbles of air, proceeds on his way.

The writer made a single observation that supports this statement. On February 10, 1933, he watched a muskrat swimming down a long canal under the ice. It approached a large bubble of air and stopped. For a moment the bubble expanded; then it shrank rapidly to half its original size. The muskrat then swam on.

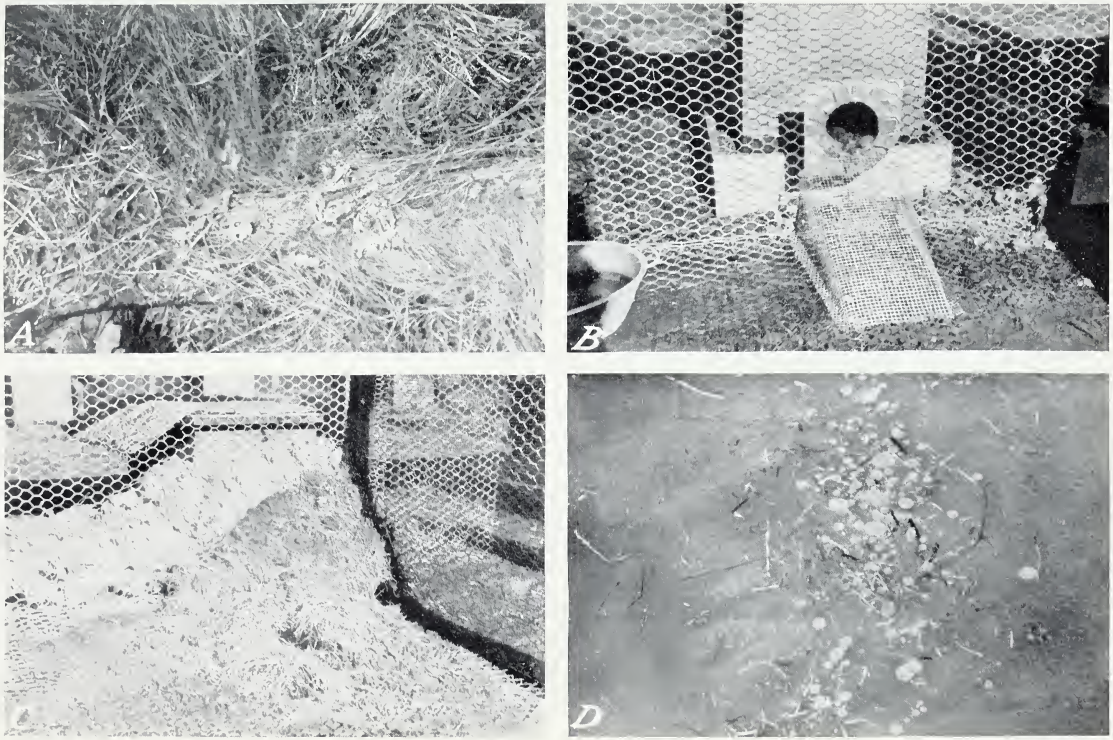
BURROW AND HOUSE CONSTRUCTION

Muskrat homes are of two general types, depending largely on the topography of the land. In the uplands, muskrats live in burrows that they dig into the banks of streams and other bodies of water. In open marshes they build more or less dome-shaped structures known as houses, or, among trappers, as beds (pl. 2). When marshes are ditched and banks formed, the animals desert their houses and live in the banks.

The entrance hole to a bank burrow is always below the normal water level (pl. 3, *A*). This enables the animal to enter without being seen and excludes some predators. The same characteristic of hiding the entrance is evident in penned muskrats (pl. 1, *C*). The burrow turns upward above water level and ends in a nest of grass or other vegetation.

Muskrat houses, which may be as much as 7 or 8 feet in diameter and more than 4 feet high, are constructed of stalks (pl. 2, *B*), roots, and peaty remains of plants and are usually built on or around a firm foundation, such as stumps, the base of a tree, old duck blinds, or a clump of myrtle bushes (pl. 2, *C*). They are seldom if ever truly dome-shaped, for one side is usually an inclined plane sloping down into the canal. The muskrat collects a large part of its building material from the bottom and sides of the canal and carries it up this sloping side to deposit it on the top of the house. As is shown by examination of a newly constructed house (pl. 2, *D*), the material, carried in the muskrat's mouth, is deposited in small, roughly crescent-shaped masses, the size depending on the kind of material used. The animal holds the bunches by the center, and the horns of the crescent are formed by the material dragging back like a mustache on each side of its mouth.

Each house contains one or more nests, rarely more than three, from each of which a passage leads to one or more plunge holes in the floor. These holes in turn lead to underground tunnels that connect with the surface several feet from the house. The nest chamber



B42190; B42198; B42199; B42178

A, Muskrat bones found on the marsh after the flood of August 1933; *B*, muskrat nest box, showing screen steps; *C*, nest box, showing how the muskrats have fastened the screen with mud and piled trash over the entrance; *D*, bubbles under ice made by muskrats.

B42203; B42206; B42205, B42201

MUSKRAT HOUSES.

A, House in short-grass marsh; *B*, house made almost entirely of cattail stalks; *C*, house built about clump of myrtle bushes; *D*, new house, showing wads of grass.

is dug and gnawed out of the solid pile of material that originally formed the house. The nests, which are usually lined with fresh grass, and the whole interior of the house are damp but not wet. They are always clean when in use.

Building operations may be carried on at any time during the year, but they vary with the season and are particularly noticeable at times of high water, when the muskrats have to work actively to keep their beds above water. Those unable to build fast enough must live on the housetops in open nests, but this rarely happens. In spring and throughout summer, presumably before each litter arrives, a new roof is added, and in fall the house is greatly enlarged for winter. At this season new houses are built, presumably by young animals. When a raccoon or other enemy breaks into the wall of a house, the muskrats soon mend the opening by stuffing it from the inside with grass or trash.

CANALS, TRAILS, AND TUNNELS

Muskrats prefer swimming to walking, and for that reason they construct an elaborate system of canals, 6 inches to a foot wide, that vary from mere muddy surface trails (pl. 3, *B*) to ditches a foot or more deep (pl. 3, *C*) and that are not visible when the water is high. Main arteries of travel are always wider and deeper than temporary leads made in search of food. In hard bottom they are usually small and are used only as connecting links between food supplies. In a bottom of peaty plant remains they are usually large. Curtis Insley reported catching 23 muskrats in Dorchester County in a trap set on the back of a snapping turtle hibernating on the bottom of a deep canal, which indicates that at least the main canals are public property for the use of all muskrats in the community.

In digging a canal, the usual method of disposal of the removed material is for the muskrat to carry it back along the canal a considerable distance and deposit it to form a small platform in the canal or a heap at one end. It would seem a much easier task to pile it along the side, but ordinarily this is not done. The platforms may be scattered at irregular intervals along the canal, 5 to 15 or more feet apart, but often they are formed at the union of several canals. They are usually built up to just above the surface at ordinary water level to form stations on which the animals may rest and look around before proceeding. Trails always lead across them, so that they are gradually worn down to the canal level and in old and much-used canals tend to become obliterated. The worn-down platforms may be added to later and used as landing places or stations for feeding and observation. A less common method of disposal of the dug-out soil is to form a fan-shaped heap at one side of the canal. Eventually this heap may become the starting point of a branch canal, in which case it forms a platform at the junction.

In dry marshes, muskrats may have surface trails (pl. 3, *D*), concealed by the grass, that lead in all directions, as do the canals. Except in size they resemble the trails made by meadow mice.

In addition to these surface canals and trails, muskrats construct a system of underground burrows, or tunnels (pl. 4, *A*), that ramify in all directions and are connected with the surface and the canals by plunge holes scattered at convenient intervals. Observations indicate that these routes are not so extensive as the canals, but that they are

often in use during the day is shown by the way the water in the plunge hole heaves as the muskrats pass and by the fact that animals are often heard chewing or digging underground when there are no surface signs of their presence. It is by the tunnels that the animals enter and leave the house, so that one is seldom seen at the surface nearby, and it is into the tunnel system that muskrats disappear when surprised on the marsh. They seldom venture far from a plunge hole.

DEFECATING POSTS

Fecal matter of muskrats on the marsh is usually formed in characteristic rodent pellets. These, at times, may be pressed together into a large mass, but even in such a case, the pellet formation is usually recognizable. Although the pellets are often scattered promiscuously about as the animal swims or walks, there is a decided tendency to deposit them in definite spots, or "posts" (pl. 4, *B*), which are found at frequent intervals over the marsh, always on a slight elevation, such as the end of a half-submerged log, a stump, a piece of sod, or a floating board. Abandoned feeding platforms are often used. Usually canals lead to or by the posts, and the trapper often sets his traps there. A post is used by more than one animal, as five or six muskrats are sometimes caught at one. After long usage, the posts are abandoned and new ones are established. Certain favorably situated places, however, may be used off and on for years, even serving several generations of muskrats.

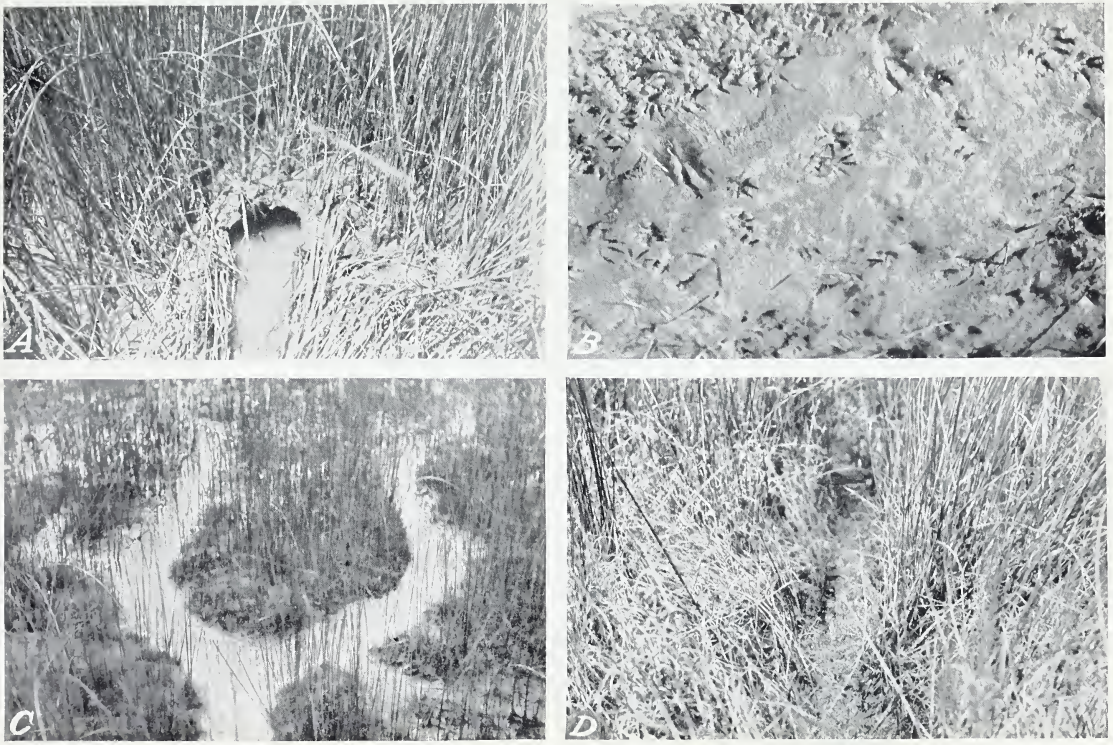
Animals kept in pens form posts, as do those on the marsh, but the excrement is usually deposited in large soft masses with little trace of the pellet formation, assumably due to differences in food. In the pens, the animals attempted to establish defecating posts on the edges of the pans, but the waste matter deposited became dislodged and fell into the water pans, fouling the drinking water. These observations suggested that artificial defecating posts might be introduced successfully. Half a brick or a small piece of concrete was placed in each of 20 pens. In most cases the muskrats readily adopted and used them, thereby reducing the contamination of the water.

FOOD HABITS

In investigating the food habits of the muskrat of the Eastern Shore the remains on the feeding platforms (p. 13) were examined and observations were made when animals were seen eating on the marsh. Many stomachs were collected, but the contents have not yet been analyzed.

It appears that muskrats will eat to some extent almost any plant found on the marsh. Certain favorites, however, form their staple diet, and no area lacking these will support a large muskrat population. Three-square sedge and the two kinds of cattails constitute four-fifth's of the muskrat's food, all parts of these plants being eaten at one time or another during the year. Some animal food is eaten, but apparently it plays a decidedly minor role in the diet.

Although many rodents store great quantities of food for future use, the muskrat does not. The nature of its food and the dampness of its habitat largely preclude food storage. Furthermore, fresh food is normally available at all times. On the Maryland marshes, when a house is opened a few plant fragments are usually found, but so small



B42181; B42172; B42207; B42192

A, Entrance to muskrat burrow in a bank; *B*, muskrat tracks in the mud; *C*, canals made by muskrats for traveling through the marsh; *D*, muskrat trails through high grass.

B42209, B42196; B42174; B42183

A, Damage to road caused by underground muskrat burrow; *B*, muskrat defecating post; *C*, muskrat feeding platform; *D*, cattail stalk cut by muskrats.

a supply would last at best for but a meal or two. Bits of food are also found on feeding platforms, but it is doubtful whether they would ever be eaten. It seems more likely that in both cases the remains are the scraps left over from a meal and discarded and so cannot be considered food stored.

Muskrats kept in pens, desiring seclusion, carry apples and carrots into their boxes to eat. The remains, however, are seldom if ever placed in a particular corner but are dropped wherever the animal finishes with them. There they stay until they decay, or, if no new food is given, until the animal is again hungry. At rare intervals a small pile of grain, perhaps a tablespoonful, is found in one of the boxes. This small quantity, about a mouthful, represents but a fraction of the available grain, most of which is not removed. Food is never found in the sleeping nest proper, which is true also of houses on the marsh, where the food remains are usually found around the inner end of the plunge hole and not in the nest. There is great variation in the food habits of individual muskrats. Some penned animals always have their boxes littered with fragments; others never do.

FEEDING PLATFORMS

In marsh areas where the ground is covered with water, feeding platforms, or rafts, to which muskrats take their food so that they may sit out of the water to eat it, are found here and there in the vegetation. The animals usually construct the platforms by breaking down a number of plants and then adding to these a few stalks (pl. 4, *C*). Not infrequently they are built on small natural elevations. They are only temporary structures and are abandoned after a few days' use. On them are usually found bits of fresh vegetation and often other food remains as well, so that a good idea of the character of the food eaten by muskrats may be obtained by examining the feeding platforms. They are not found along all canals, however.

VEGETABLE FOOD

Many of the plants used by muskrats on the Maryland marshes could not be identified at the laboratory, but those on which they are known to feed are given in the following paragraphs. They are arranged approximately in the order of their importance, although some were noted as used only once. J. B. S. Norton, of the University of Maryland, identified most of the grasses and grasslike plants, and S. F. Blake, of the Bureau of Plant Industry, United States Department of Agriculture, identified *Cyperus ferax* and *Juncus roemerianus*.

Three-square (*Scirpus olneyi* or *S. americanus*) is the chief muskrat food on many marshes. All parts of the plant are used at some season: during spring and early summer the stems and leaves are eaten; during fall and winter the roots and rootstocks. The abundance of this plant largely determines the number of muskrats on some marshes.

Saltmarsh bulrush (*Scirpus robustus*) is not common on the Gibbs marsh, but from observations made elsewhere it seems to be a good muskrat food, the equal, or nearly so, of three-square, and its parts are similarly available at different seasons.

Broadleaf cattail (*Typha latifolia*) rivals the three-square in importance. It loses first place not because of its lack of value as a

food, but because its distribution is irregular and there are great areas where it does not grow. It is usually found in dense beds, which as a rule support a large muskrat population. During spring and early summer the shoots are eaten. Later the stalks are cut into at the base, and the heart, which is still tender and sweet, is hollowed out (pl. 4, *D*). This often leaves the stalks standing dry and dead until a gust of wind blows them over. During winter the roots and rootstocks are eaten.

Narrowleaf cattail (*Typha angustifolia*) is a favorite food but because of its scarcity is of little importance. It usually does not form dense beds, as does *T. latifolia*, and is even more scattered in distribution than that species. It is eaten in the same seasonal manner.

Wild reed (*Phragmites communis*), a favorite food, grows in beds of limited distribution, in which muskrats are always found. Both stalks and roots are eaten, the former throughout the summer.

Saltgrass (*Distichlis spicata*) is a short grass that grows in the same territory with three-square. Late in summer and on through winter and spring, the underground parts are eaten to a considerable extent. The stalks are used for houses and probably for food. On August 10, 1932, a house built entirely of this grass was found on the Gibbs marsh.

Beaked-rush (*Rynchospora pallida*), a plant of restricted distribution, is of doubtful value. It is sometimes used for food and building but is probably of no great importance.

Spikerush (*Eleocharis* sp.), a short plant that grows in shallow water, is frequently found on muskrat feeding platforms and is apparently often eaten. It is also used in building, and one house found was made entirely of it.

Big cordgrass (*Spartina cynosuroides*) is of doubtful importance. It was found in only a few of the marshes visited, where it seemed to be consumed to some extent, though in such cases better food was scarce. It was also used for houses.

Wild millet (*Echinochloa walteri*), distinctly a second-choice food, is not abundant and seems to be eaten only when preferred food is absent. It is used for houses.

The sweet sedge *Cyperus ferax* is not abundant on the marshes visited. It is used to some extent for houses and for food but is of little value.

Needlegrass (*Juncus roemerianus*), said to be of considerable value as muskrat food in Louisiana (*1*), was found in abundance on only one marsh in Maryland, where, although it was used for building, no evidence of its use as food could be found. Eastern Shore trappers are of the opinion that this plant is of no use as muskrat food. It usually grows in dense beds, in which there is little other vegetation. Early in May 1934 several of these beds were visited, and it was found that the muskrats living there were feeding to a limited extent on the tender new shoots. They had used all parts of the plant, however, in building. Apparently the plant becomes less palatable as it approaches maturity early in summer, because by mid-June its use as food had practically ceased and the animals were eating the three-square that grew several hundred feet away.

A species of goldenrod, *Solidago tenuifolia*, a rather late autumn flower, is apparently of little importance to the Maryland muskrat. It does not seem to be eaten, but two or three stalks were found cut off on October 1, 1932.

B42185; B42173; B42176; B42179

A, Poison-ivy vines from which the muskrats have gnawed the bark; *B*, spotted turtles dead on top of a muskrat house, perhaps killed by muskrats; *C*, salt-water mussel shells on a muskrat feeding platform; *D*, open nest in the marsh—such nests are occupied by sick muskrats.

B42188; B42189; B42186; B42187

MUSKRAT TRAPPERS

A, Setting muskrat trap; *B*, removing muskrat from trap; *C*, getting live muskrat by its tail; *D*, placing live muskrat in can for transporting.

Saltmarsh fleabane (*Pluchea camphorata*) is of little value. A few stalks were found cut off, but apparently the plant is seldom eaten.

Marshmallow (*Althaea officinalis*), an herbaceous plant, apparently is not of great value as food for muskrats, although it is used in building. A few stalks were found cut off.

Waterlily (*Castalia odorata*), a beautiful plant, is used to some extent as muskrat food but is of no great value. It was not found to be used for building.

Dodder (*Cuscuta* sp.) is of little importance because of its scarcity. On July 28, 1931, a muskrat was observed eating the golden threads of this plant at the water's edge of a little lake near Solomons Island, Md.

Iris, although an attractive food, is so rare on muskrat marshes that it is of little importance. A few stalks of one species were found partly eaten.

Waxmyrtle (*Myrica cerifera*) may have considerable food value, as the leaves, bark, and wood are often eaten in winter and spring.

Small pine trees (*Pinus taeda*) grow on the higher parts of the marsh, and the muskrats frequently build their houses about their bases. Often a tree is barked above the top of a house to a height of more than a foot. Trees 6 inches in circumference are sometimes completely girdled and thus killed.

Poison-ivy (*Rhus toxicodendron*) is very abundant on the higher parts of the Maryland marshes. Muskrats often gnaw the bark from the vines (pl. 5, *A*), and they eat the leaves to some extent.

ANIMAL FOOD

Although it makes up but a small percentage of their diet, some animal matter is eaten by muskrats. This is hardly to be wondered at, as practically all rodents eat meat at times, and some eat it regularly.

Frequently, spotted turtles (*Clemmys guttata*), which are numerous on the marsh, are found on the tops of muskrat houses with their heads nearly severed but with little if any of the flesh eaten (pl. 5, *B*). When spotted turtles, painted turtles (*Chrysemys picta*), and musk turtles (*Sternotherus odoratus*) were placed in the pens they were killed and partly eaten. Usually only the legs and head were pulled out and chewed off, but in the case of a small musk turtle the plastron was partly cut away and much of the tissue removed.

Blue crab (*Callinectes sapidus*) remains are often found on the feeding platforms in Maryland, and when blue crabs were placed in the pens, they were readily eaten. The legs and claws were removed and the tissues eaten, and then the plastron was bitten into and the body muscles were partly devoured.

Four tests were made to determine whether the Eastern Shore muskrats eat fish. Small fish, caught on the marsh, were placed in the drinking pans late in the evening. In three tests they were gone by morning. In the fourth test the posterior half of one fish was found beside the pan. Lantz (*13*) reports that muskrats eat fish, chiefly sluggish kinds, such as carp.

Where salt-water mussels occur on the Dorchester County marshes their shells are often found on the muskrat feeding platforms (pl. 5, *C*).

Johnson (*11*) and others report that fresh-water clams also are often eaten in large numbers.

Hollister (*9*) records that muskrats sometimes eat dead birds. To test this, five nearly grown but unfeathered starlings (*Sturnus vulgaris*), and three adult house sparrows (*Passer domesticus*) were placed in the pens on May 5, 1933. Within 3 hours all but one adult sparrow had disappeared. It remained in the pen for 2 days and then was removed in cleaning. These observations indicate that Eastern Shore muskrats may eat dead birds found on the marshes.

BREEDING HABITS

BREEDING SEASON

There is considerable difference of opinion as to the length of the muskrat's breeding season in Maryland. Some trappers claim that it extends from mid-March to mid-September; others, that it begins earlier and continues later. That it is well under way in March is shown by the number of pregnant females caught then.

In an effort to acquire definite information on this subject, the cooperation of several local trappers on the Gibbs marsh was obtained (pl. 6). Their 1932 reports of pregnant females trapped are as follows: One female with four embryos as large as mice, January 26; four large embryos, week of February 1; and one female that gave birth to two offspring while in the trap, February 19. The 1933 records, more complete and more reliable because most of the specimens were obtained for examination, are as follows: One large embryo, five small embryos and seven small embryos collected January 26, February 24, and March 3, respectively; five large embryos reported March 8; five small embryos collected March 9; five small embryos collected March 10; and six large embryos almost ready for birth reported March 13.

Mr. Gibbs, who breeds muskrats rather extensively, is of the opinion that most first litters are born in May. In order to gather information on the subject, he opened 100 muskrat houses on May 15 and found young in 25 of them.

On the Eastern Shore, kits, or young muskrats, are frequently caught in the early part of the trapping season, which usually extends from about February 1 to March 15. On the Gibbs marsh, a kit weighing about 6 ounces was caught on March 8 and one weighing 5 ounces on March 13. In the experimental pens, the latest litter was born on October 30 (1931).

From these records it appears that muskrats may breed every month in the year with the possible exception of November and December. Most of the young are born, however, from mid-April to mid-September. Two litters in one year were the most obtained from pen-raised animals.

GESTATION PERIOD

There has been considerable difference of opinion as to the length of the gestation period in the muskrat. Lantz (*13*) states that it is probably 21 days, as for the common house rat, but definite experiments conducted during the 1933 breeding season to ascertain its length indicates a longer period, of 29 or 30 days.

In the experiment, known breeders from the previous year were segregated in five units, each unit consisting of a male between two females, each in a separate pen. At first, matings were made every 10 days; later, every 15. On mating day the male in the middle was placed in the pen on the left and allowed to remain overnight. The next morning he was placed in his own pen and remained there one night. The following day he was placed in the pen on the right for one night, following which he was returned to his own pen to remain until the next mating day. Under the 10-day interval system one litter of four young was produced on May 16 by a female that had been with the male on the ninth, nineteenth, and twenty-ninth days previous. Under the 15-day interval plan, a young animal was found dead in one of the nests on the morning of July 30. It had evidently been born the night before and was perfectly developed in every way. The female had been with the male on the fifteenth and thirtieth days preceding.

Three weeks later the hurricane wiped out the breeding stock and ended the work for the year, but from the two records obtained it would appear that the gestation period of the muskrat is 29 or 30 days. The other supposition possible would place it at the fifteenth to nineteenth day, a difference that is too great. Further information must be obtained, however, before any more definite statement can be made.

SIZE OF LITTERS

The number of young produced by a muskrat at a single litter is variable. The average number of young found by Mr. Gibbs in the 25 muskrat houses on May 15 was 5. Arthur (*1*) records 25 sets of embryos collected by trappers in Louisiana that averaged 3.88 embryos a set, 7 being the most found in any one animal. He also records personal observations on 1,058 sets of embryos that averaged 3.846 embryos a set. From this it appears that in Louisiana the average is slightly less than 4. Johnson (*11*) reports a female with 11 embryos in New York State; and Lantz (*13*) gives a Biological Survey record of one with 13 but does not state the locality. In the Maryland investigations, embryos from 10 trapped animals averaged 4.4 a set, 7 being the most in any one uterus.

In pens, the litters are not so large as those on the marsh, according to the following accurate data obtained on 27 litters of muskrats that were born in the experimental pens: 1 young in each of 2 litters; 2 in each of 8; 3 in each of 7; 4 in each of 9; and 5, the most produced, in 1, making the average 3 young to a litter.

THE YOUNG

At birth, young muskrats are covered with dark fur, so short and fine that it is scarcely visible; the feet and the tail, which is slightly flattened, are bright pink; and the eyes are closed. There is great variation in the time at which the eyes are opened; observations show that it is from 11 to 15 days after birth.

When attached to the nipples the young are very tenacious and if the mother is disturbed and driven from the nest often hang on and allow themselves to be dragged over the ground or through the water for a considerable time before they release their hold. In the pens,

females sometimes climb up the wire and hang there for several minutes with the young still attached. If the mother desires to remove a kit from the nipple, she seizes it gently with her mouth and pulls it away. The young may suckle for as long as 21 days, although 15- or 16-day periods are more common. They begin to nibble solid food before they stop nursing.

Immature muskrats are comparatively noisy animals. When disturbed in the least they utter complaining squeals, although the adults are usually silent. The mother shows great concern when the young call and runs to them at once, often attempting to carry them away in her mouth.

NATURAL ENEMIES AND CHECKS

PREDATORS

Several birds of prey are said to feed to some extent upon muskrats. Many trappers claim that bald eagles, owls, and some of the hawks are outstanding enemies. Other trappers express the opinion that these birds do little damage. Red foxes, raccoons, and weasels are sometimes destructive to muskrats, and snakes are commonly reported as enemies. Muskrats are largely nocturnal in habits, and though they are occasionally seen in the daytime they are very cautious and alert. They usually stay close to a plunge hole or tunnel and at the least alarm, vanish. This makes it difficult for an enemy to catch them.

Even when birds and mammals are seen eating muskrats, however, it does not necessarily follow that they have killed them. Practically all birds of prey are scavengers, particularly the turkey vulture and bald eagle and, to a less extent, the marsh hawk. In June 1932 a bald eagle was seen to drive a turkey vulture from the top of a muskrat house where the vulture had been eating something. The house was a considerable distance from the observer, and by the time he reached it, the eagle, which in the meantime had been eating, had flown away. Bone fragments of a partly grown muskrat were found. Had only the eagle been seen, it might have been held responsible for the killing, but as the observer saw the eagle drive the vulture from the food, the muskrat must have been dead even before the vulture found it.

The bald eagle (*Haliaeetus leucocephalus*) naturally comes under suspicion as a potential muskrat foe. Muskrat remains were found in approximately half of 62 eagle pellets examined, 44 collected from beneath an eagle's perch and 18 from beneath an occupied nest. Inasmuch as the remains from one muskrat might have been represented in several pellets, it could not be determined exactly how many animals had been eaten. Examination of food remains from two old eagle nests, each of which contained the accumulations of more than 30 years, revealed in one case 30 skulls and numerous other remains of muskrats and in the other, in which a great many miscellaneous food remains were noted, only a single muskrat skull.

Of the hawks, the marsh hawk (*Circus hudsonius*) has the worst reputation as a muskrat destroyer. This is due to its habit of feeding on trapped animals rather than to its habits as an independent killer. During the 1933 season five marsh hawks were killed while eating trapped animals, but at no time during these investigations was a marsh hawk seen capturing a muskrat. Other hawks, particularly

the larger species, such as the red-tailed hawk (*Buteo borealis*), are said to prey to some extent on muskrats, but the writer found no evidence of this. It does not seem that hawks do great damage to muskrats.

Trappers regard owls as much more destructive to muskrats than hawks. The barred owl (*Strix varia*) and the great horned owl (*Bubo virginianus*) are considered equally harmful. Pellets found on the marsh, probably some from each species, contained muskrat fur. The few stomach examinations made failed to reveal muskrat remains. Fisher (*6, 7*) reports muskrat remains in the stomach of a great horned owl. Until more definite information can be obtained both species must be regarded as potential muskrat destroyers.

The long-eared owl (*Asio wilsonianus*) and the barn owl (*Tyto alba pratincola*), also found around marshes, may occasionally catch young muskrats, although two stomach examinations of the latter failed to confirm this suspicion. In Louisiana (*1*) barn owls are said to feed on very young muskrats to a considerable extent, but this report is based on scattered pellets, the source of which might be in doubt. An examination of the food remains in a barn owl's nest that was found in a hollow tree a short distance from the Gibbs marsh revealed that the following animals had been eaten: 6 muskrats, 282 meadow mice, 5 wood mice, 1 house mouse, 1 brown rat, 8 short-tailed and 6 long-tailed shrews, 1 flying squirrel, 1 hummingbird, 1 blackbird, and 3 unidentified birds. It is seen that muskrats were comparatively infrequent victims.

The turkey vulture (*Cathartes aura*), although frequently seen eating muskrats on the marsh at all seasons, is not regarded by any of the trappers as a menace to muskrat life. Its reputation as a pest rests rather on its habit of feeding on dead muskrats. It frequently eats muskrats dead in traps, particularly when the traps are not visited for several days. Were it not for this, vultures would be decidedly beneficial on a marsh, for they remove the dead bodies that would otherwise decay and possibly pollute the water.

Crows (*Corvus brachyrhynchos*) feed upon trapped muskrats, a fact that few trappers realize. This habit is probably confined to individual crows rather than to the species as a whole. As their beaks are not fitted for tearing the skin, the crows usually feed about the natural openings and therefore do little damage to the pelt.

From observations made on the Maryland marshes it seems probable that in many cases sick animals spend the daylight hours in open nests on the marsh (pl. 5, *D*), where they are exposed to the sharp eyes of diurnal birds of prey (p. 21). Their weakened condition makes escape improbable if they are attacked. However, it seems desirable to have a moderate number of diurnal predatory birds patrolling a marsh to destroy sick animals, for in this way an epizootic may be prevented.

Red foxes (*Vulpes fulva*) sometimes kill a number of muskrats, particularly if their den happens to be on an island in the marsh. Several Maryland trappers report finding muskrat remains, both young and old, about fox dens, and practically all trappers regard foxes as serious pests on a marsh. On June 27, 1934, a fox den from which the old fox had recently removed her cubs was visited. Among the food remains were found the skulls and other bones of 12 adult muskrats. Muskrat remains were more than twice as abundant as

all other foods combined, showing that these rodents are a favorite prey of the fox. No remains of young muskrats were found, which indicates that the fox den was probably deserted before young muskrats were abroad in any considerable numbers.

Individual raccoons (*Procyon lotor*) sometimes form the habit of breaking into muskrat houses, probably in search of young, and will break open all the houses in a large area in a surprisingly short time. Whether they kill adults has not been established. A mass of raccoon fecal waste found on the marsh on August 10, 1932, was composed largely of muskrat fur. When a raccoon forms the house-breaking habit it does great damage, of course, but as a whole the species cannot be considered a serious pest

Weasels (*Mustela* sp.) are fairly common around marshes, and some trappers regard them as pests. Considering the agility and strength of the muskrat, it would seem to be a dangerous animal for the weasel to attack. Occasionally the weasel does so successfully, however. One trapper reports that while moving a pile of cordwood he uncovered a weasel's den containing two young muskrats partly eaten. From this it appears that weasels may be destructive on a marsh, to young animals, at least.

Although snakes are commonly reported as enemies of muskrats, no evidence of such enmity was found in this investigation. There are no poisonous snakes on the Maryland marshes, and it is doubtful whether the black snake (*Coluber constrictor*) and king snake (*Lampropeltis getulus*) that do occur, being nonpoisonous, could cope with mature muskrats. Certainly they could not eat them.

PARASITES

Trappers report that occasionally on a warm day, particularly in dry years, they find their clothes so full of vermin from the muskrats caught that it is very uncomfortable to wear them.

Only two species of ectoparasites were taken and identified during this investigation. Both were mites found on muskrats caught on the Gibbs marsh in 1933 and identified by H. E. Ewing, of the Division of Taxonomy, Bureau of Entomology, United States Department of Agriculture. Specimens removed from a muskrat on February 4 were identified as the mite *Tetragonyssus spiniger;* and others, taken on February 24, as a new species of the genus *Listrophorus*, a group of hair-clasping mites. A few fleas were observed on a pen-raised muskrat but escaped before they were identified. On February 22, 1934, a muskrat was found frozen on the marsh. It was heavily infested with mites that Ewing later identified as *Ichoronyssus spiniger*.

Johnson (*11*) lists 13 trematodes, 4 nematodes, and 3 cestodes as parasites of the muskrat. During these investigations, J. E. Shillinger, of the Section of Disease Control, Bureau of Biological Survey, United States Department of Agriculture, identified two species of endoparasites that he removed from penned animals when making post-mortem examinations. One, a tapeworm 4.5 inches long encysted in a liver, was identified as *Taenia crassicollis*, a species reported in muskrats by Johnson also. The adult of this species is found in the cat, and encysted larval stages occur in various rodents. The other species, nematodes about 3 inches long found in the heart and larger blood vessels of two animals, was identified as *Dirofilaria*,

probably *D. immitis*. Closely related if not identical parasites are found in dogs, particularly in the South, and cause loss of vitality or even the death of the dog. They are transmitted from animal to animal by mosquitoes, but their life history is not known.

On June 30, 1933, the body of a muskrat was found floating in the water on the marsh. An autopsy performed at the station revealed that the liver was infected with flukes, which had apparently caused death. They were identified in the Section of Disease Control as *Parametorchis* sp. Some authorities believe that they are the same flukes that infect cats, rats, and many other vertebrates. At present no specific name is given them.

DISEASES

Many promoters, anxious to sell live muskrats for breeding stock, have assured prospective buyers that these animals are always healthy and free from disease. Nearly all trappers have supplied evidence to the contrary, stating that they sometimes find dead bodies on the marsh that may bear no signs of injury but often show extreme emaciation. Some years many such animals are found. giving evidence of an epizootic.

In the course of this work, three animals were found sleeping in open nests on the marsh, but only two of them could be examined. Both had sore eyes, and one had an injured hind leg. Another open nest found on the marsh contained one dead muskrat. Two trappers offered assurance that these open nests are always occupied by cripples and sick animals (pl. 5, *D*). Whether all sick muskrats make such nests or only those having certain types of disease is not known.

During the Maryland investigations all animals that died were examined by Shillinger, and his autopsy findings on animals dying from injury or disease form the basis for the remainder of the section on diseases.

One animal trapped on the Gibbs marsh and saved for examination because of its emaciated condition was found to be suffering from some kidney trouble, the kidneys showing a degenerated condition.

Abscesses are often found on otherwise healthy animals caught on the marsh. Usually about the size of a marble, they are located on almost any part of the body, just under the skin, and seldom, if ever, show any external symptom except a swelling. When removed they are found to consist of a tough cyst filled with a yellowish-green pus. It is believed that these sacs have their origin in a wound, probably received while fighting. If left alone the sac usually bursts and drains. A penned muskrat, in attempting to clean the draining pus sac, usually becomes infected about the mouth and dies of generalized pyemia. There is indication that the same thing occurs on the marsh.

When wild animals of almost any kind are caged there is great danger that they will become diseased. Many diseases to which they are subject in pens are not common in the wild, as a rule, but are caused by unnatural and unhealthful conditions and food. Some are the direct result of pollution of food or water, and strictest hygiene must be practiced to prevent losses. Most diseases found in the penned animals on the Gibbs marsh were of the type resulting from pollution from contamination.

Septicemia, commonly known as blood poisoning, caused the death of two muskrats. In each, the intestine was affected and it appeared possible that this was the focal point of infection.

Coccidiosis, a common disease in penned muskrats and in animals living on abnormally dry marshes, caused the death of two animals and slightly infected another. It is caused by protozoan organisms that are present in many animals, although usually only in small numbers. It is when the animals are constantly exposed to pollution that serious infection occurs.

Inflammation of the eyes is the most troublesome disease found, although only two muskrats died as a direct result of it. The eyes become inflamed, and a thick discharge seals them. The disease in itself does not seem serious, but when the animal cannot see it will not eat. Its vitality is thus lowered, and this indirectly causes death. External treatment of the disease was a failure. The animals became so vicious that it was impossible to apply a dressing even by squirting it from an oil can. Several affected animals recovered completely without treatment. Several animals that died of other diseases also showed inflamed eyes. When sick, the animals will not gnaw to wear down the teeth, which soon grow unnaturally long and cause trouble. In one such case the lower incisor teeth cut off the upper ones and then continued to grow until they completely severed the end of the nose.

One muskrat died of leukemia. The spleen, which was enlarged, showed an extensive liquefaction and necrosis.

One animal was found to have calcareous concretions, or gallstones. An encysted tapeworm found in the liver may have contributed to the condition. No similar lesions were found in other animals on the marsh.

SUMMARY

An intensive though incomplete study of the life history of the Eastern Shore, or Virginia, muskrat (*Ondatra zibethica macrodon*), made in Dorchester County, Md., from 1930 to 1934, in which both animals on the marshes and animals confined to pens under controlled conditions were observed, has produced the evidence and established the facts that follow.

There is evidence that the black and brown color phases of the Virginia muskrat are inherited, black being a recessive and brown a dominant character.

An unusually high flood, as in August 1933, extreme drought, as in 1930, and extreme cold, as in February 1934, are disastrous to muskrats.

The food of the muskrats on the marshes consists chiefly of three-square sedge and cattails, but almost every plant found is eaten to some extent. Some animal food is taken.

The breeding season extends throughout most of the year, but there is an intensive breeding period from mid-March to about the first week in September. The gestation period appears to be 29 or 30 days. On the open marsh the litters average between four and five young; in pens, three. Muskrats may breed three times a year; but the penned animals produced only two litters a year at most.

Three species of ectoparasites, all mites, found on marsh animals were identified as *Tetragonyssus spiniger, Ichoronyssus spiniger*, and a

new species of the genus *Listrophorus*, a group of hair claspers. Three species of endoparasites were obtained and identified: A tapeworm (*Taenia crassicollis*) and a nematode of the genus *Dirofilaria*, probably *D. immitis*, were found in penned animals and flukes (*Parametorchis* sp.) in a marsh animal.

Evidences of abscesses were noted and the following diseases diagnosed: A degenerated condition of the kidney, septicemia, coccidiosis, inflammation of the eyes, and leukemia. Gallstones were found in one animal.

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U. S. GOVERNMENT PRINTING OFFICE: 1938